




## Article

# Virtual Environments and Augmented Reality Applied to Heritage Education. An Evaluative Study

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Received: 28 February 2020; Accepted: 26 March 2020; Published: 30 March 2020



**Abstract:** Technological advancements have provided heritage with new learning environments via the use of virtual and augmented reality, which can foster the accessibility and understanding of culture and propose new ways of interacting with heritage. Therefore, in this study, a systematic evaluation is carried out of n=197 heritage education programs listed in the database of the Observatorio de Educación patrimonial en España (OEPE) (the Spanish Heritage Education Observatory–SHEO) which, in their descriptions, integrate the use of virtual environments and/or augmented reality to promote learning on the part of the user. The objectives of this study are: (1) to analyse the state of the art, (2) to evaluate the quality of their educational designs via the “analysis and assessment sequential method for heritage education programs” (SAEPEP-OEPE) and (3) to identify variables which can be improved or which have a significant influence on the quality of the programs. Highlights of the results include: (a) the increasing implementation of these technologies in heritage education programs, with the greater presence of virtual resources than of learning environments, (b) the low level of the scope of educational quality in their designs, particularly their assessment, and (c) the inclusion of advanced technologies slightly decreases the specificity of the educational design.

**Keywords:** heritage education; virtual environment; augmented reality; heritage programs; evaluation

## 1. Introduction

### 1.1. Virtual Reality and Augmented Reality Applied to Heritage Education

The emergence of digital and portable technology, which enables us to experience heritage in situ, provides great opportunities for heritage education, and the changing role that this type of technology provides to the transmission of knowledge must be recognised. Nowadays, the digital realm is the perfect context for heritage education [1], due to the fact that processes of knowledge, comprehension, enhancement, awareness, and enjoyment of cultural heritage take place on the internet, making it a means of identity in a universal context [2,3]. Therefore, several studies [4,5] have analysed the extent to which the digital environment democratises, educates, and socialises heritage, which has gone from being a physical place to possessing a virtual facet. Learning in these digital environments is a process which is free from restrictions; it proposes new rules, tools for communication, and contexts for interaction. In this regard, virtualisation has supposed one of the greatest impacts on the mediation of heritage, the most common use of which, up to the present moment, has been the creation of educational itineraries in historical sites [6].

The first uses of virtual reality (VR) applications focusing on cultural heritage in the classroom employed gamification as a learning technique [7]. Nowadays, there is an abundance of research on educational proposals for working with heritage based on games created *ex profeso* [8] or making use of pre-existing videogames and their historical settings, such as *Assassins Creed* or its educational versions, *Classcraft* and *Minecraft Education* edition [9]. In the field of heritage education, there is currently a significant increase in the presence of applications based on geolocation, augmented reality (AR), and virtual reality (VR).

Some authors consider AR and VR as new tools for accessing information and that they facilitate learning processes [10], and this premise has already been addressed by some studies that raise research on how the use of these tools contributes significantly to the teaching–learning processes from different areas of knowledge [11,12]. In this way, if VR supplants reality and makes it possible to create inexistent settings (be they real or imaginary), AR complements it, enabling the learner to interpret, for example, archaeological remains or modified urban areas. Both techniques make it possible to develop immersive contexts which offer a greater degree of sensorial perception [13] via the recreation of environments [14] and inexistent places and constructions [15], to visualise the whole or a part of an object without damaging the original [16], to walk a route upon which virtual information is superimposed on places of interest [17], to be accompanied by a virtual guide during a route [18], and to play interactive games in which virtual and real aspects are combined [19,20]. All of these possibilities can be offered via specific digital platforms, virtual museums [21], and even *in situ*, making use of GPS [18] and QR codes [22]. In addition, the use of other devices, such as Google Glass [23] or other types of visors, have been used for this objective, albeit with the limitation that it is an added resource which the user must have at his/her disposal.

At the present time, work with 3D and 360° images, the use of global positioning systems, the introduction of GoPro cameras, drones, and photogrammetry are in the vanguard of education. This new technological generation is modifying the way we relate to heritage, leading to a broadening of knowledge, an improvement in the understanding of cultural assets, a greater degree of global accessibility, and an increase in approaches and methodologies with which we can interact with heritage. These new trends can be seen in projects such as *Inception*, in which 3D representations are created and added to a European cultural heritage database which allows access to any user with the aim of facilitating the understanding of heritage as a relationship of unique identities to be transmitted to future generations by way of devices and innovative methodologies [24,25]. The *Formapps* project is also worthy of note, which promotes educational innovation in its digital competence via virtual spaces, networks, and devices [26]; the *Baética* project, which creates and develops learning communities by way of multidisciplinary research projects on archaeological sites which culminates in a virtual hypothesis of the site and the 3D digitalization of the monuments [27]; the *SmartMarca* project, an Italian proposal for the transmission of content in AR and VR on cultural heritage, which seeks to provide students with learning methods and content construction through these applications. Moreover, the study evaluates its potential as an attractive, interactive, realistic, and close-to-the-student medium that improves the reworking and acquisition of new knowledge [28,29]. As far as applications are concerned, there are apps such as *VirTimePlace*, which allows the user to visit historical sites with the aid of a 3D visor; the online assistant *Virgo*, which includes a catalogue of items in 360 degrees and makes it possible to create exhibitions in three-dimensional virtual spaces; and the *Smart Coolture* resources, which provides the user with virtual experiences to disseminate and preserve heritage and to make it accessible.

### 1.2. This Study

In order to identify what work is being carried out on these new relationships between heritage sites, digital applications (particularly AR and VR and virtual environments) and education processes, we evaluated a selection of cultural heritage education programs which specify the use of virtual environments or virtual or augmented reality in their educational design. The main aim of this study

was to analyse the educational components of heritage education programs which make use of these emerging technologies.

The relationship between heritage education and technology is gaining presence in research in Spain [30]. Led by the Observatorio de Educación Patrimonial en España (the Spanish Heritage Education Observatory—SHEO), there has been a large number of educational research projects carried out in recent years in heritage contexts with ICT resources (Information and Communication Technology). Particularly worthy of note are the analyses of the use of digital technologies in the areas of archaeology and heritage education [31], the use of ICT and contemporary heritagization processes [32], and the most recent projects regarding the study of apps [33–35] which follow in the footsteps of the initial projects carried out in Great Britain [23]. Over the past few years, studies on virtual heritage [36], Big Data [37] and heritage, ICT, and inclusion [38] have been carried out in other parts of the world.

Although there are previous studies on the evaluation of heritage education programs, there are none which evaluate whether the fact of introducing these types of devices into the educational design supposes an alteration of their planning, or whether these types of devices are already totally integrated or if the process of implementation is still in progress. The initial hypothesis of this research suggests that we are facing an emerging process in which there is an increase in heritage educational programs that integrate virtual environments, AR and VR, which do not have a quality didactic or evaluative structure.

Therefore, the specific objectives of this study are:

- SO1: To analyse the typology of heritage education programs which use VR, AR, or virtual environments.
- SO2: To evaluate the quality of the educational design of heritage education programs which specify the use of virtual environments, AR and VR in their planning.
- SO3: To analyse the correlations between the quality standards of these heritage education programs.
- SO4: To differentiate the quality of the programs according to whether they are publicly or privately owned, the specificity of the program and the category of heritage in which these digital resources are implemented.

## 2. Materials and Methods

The approach of this study is based on the Analysis and Assessment Sequential Method for Heritage Education Programs (SAEPEP–OEPE) [39] in its most advanced phase of implementation, corresponding to the evaluation of programs based on basic standards via the application of the Q-Edustage [40] scale. This scale evaluates the level of educational quality of heritage education programs with proof of validity and reliability for the implementation of educational practices based on the design of effective actions.

### 2.1. Sample

The selection of the study sample was extracted from the database of the Spanish Heritage Education Observatory (SHEO). This institution currently has  $n=2156$  educational programs relating to heritage. A search of these programs was carried out based on the descriptors “virtual environment”, “VR”, and “AR”, which resulted in a valid sample of  $n=197$  programs for this study.

This sample was, in turn, analysed in two successive phases: one encompassing the whole of the sample and another comparative analysis of two subsamples selected following a discrimination of the programs in relation to the consistency of the descriptors of interest, those which appear in a partial (they are only named) or specific way (their use, objective or manner of implementation is described). These subsamples correspond to  $n=113$  and  $n=84$  respectively.

## 2.2. Data Collection Tool

The Q-Edutage scale is an assessment tool which forms part of the previously mentioned SAEPEP-OEPE method, designed by way of a review of literature based on quality indicators of heritage education programs and on the methodological criteria derived from the Plan Nacional de Educación y Patrimonio (National Education and Heritage Plan) [41], following the assessment model proposed by Stake [42]. The scale has previously been validated via expert judgement [43] consisting of 17 members from 9 knowledge areas, who have analysed its empirical and content validity [44] in accordance with its coherence, relevance and congruence with regard to the object of evaluation on a 4-point scale, calibrated via the item response theory (IRT) on an assessment of 330 programs [40].

The scale consists of 14 items resulting from this procedure which respond to various facets and aspects of the quality of the programs. This tool possesses a high degree of reliability and discrimination between the 4 levels of the variables [45], which makes it possible to adequately identify the quality of the programs included here. It is a brief and precise tool which does not present bias independently of the assessor applying it.

The 14 items which make up the scale [45], make it possible to accurately discriminate four levels of quality via a Likert scale which contributes towards detecting outstanding programs and to optimising the rigour of the assessment and the planning of programs (“is not achieved”, “is achieved with conditions”, “is achieved”, and “is achieved with quality”). For its correct use, a rubric for assessment is used which helps to determine the scoring of the items (this can be requested from the first author). The indicators (see Table 1) respond to aspects of identification of the program, such as the contact and the descriptors which define it, the holistic conception of the heritage, if the heritage is presented in a complete and multiple way in all of its categories, the specification of the typology of the project carried out, the description of its bases or principles or the audience to which it is directed and if it has annexes; and to the key elements of an educational plan: justification, objectives, contents, methodology, resources, assessment and repercussion.

**Table 1.** Coding of variables according to quality standards.

Item	Standard	Coding
i01	Contact information with the management and/or design team, planning and implementation.	Contact
i02	Descriptors that define the program.	Descriptors
i03	Holistic conception of heritage in its nature (material and immaterial) and its qualities (archaeological, historical, documentary, artistic, etc.).	Heritage
i04	Specification of the type/typology of the project developed (educational program, educational project, educational design, educational action, isolated activity, etc.).	Typology
i05	Description of the bases, principles, and criteria on which the program is established.	Criteria
i06	Specification of the target audience.	Audience
i07	Incorporation of documentary annexes (memory, images, videos, teaching materials, etc.).	Annexes
i08	Project justification.	Justification
i09	Description of the objectives to be achieved in the development of the program.	Objectives
i10	Presentation of the contents of the program.	Contents
i11	Methodological approach and teaching and learning strategies.	Methodology
i12	Definition of resources, formats, media, and technology used.	Resources
i13	Determination of assessment systems or tools.	Evaluation
i14	Evaluation of the impact and repercussion of the proposal.	Impact and Repercussion

The Cronbach’s alpha (Table 2) and Guttman (Table 3) statistics show that the questionnaire is suitably reliable for analysis. The criterion agreed upon by different authors is that a Cronbach’s alpha value of between 0.70 and 0.90 indicates a good internal consistency for a one-dimensional scale [46,47].

**Table 2.** Cronbach's alpha reliability statistics.

Cronbach's alpha	Standardized Cronbach's alpha
0.91	0.91

**Table 3.** Guttman's reliability statistics.

Guttman L1	Guttman L2	Guttman L3	Guttman L4	Guttman L5	Guttman L6
0.84	0.91	0.91	0.95	0.89	0.92

### 2.3. Data Analysis

As far as the procedure for data analysis is concerned, the sample and resulting subsamples were assigned to three expert assessors familiarised with the assessment rubric of the items and, in a previous stage, have gone through a registration sequence which implies searching for and locating programs, a discrimination phase for their inclusion in the database, and the later inventory via a tool with 42 fields to be completed. The data were analysed with the XLSTAT v.2019.3.2 program by way of descriptive statistic processing of the items which make up the scale. After this, Pearson correlation tests were performed, along with non-parametric tests (Mann–Whitney U test and Kruskal–Wallis) on the items and the variables “type of entity”, “type of project”, and according to the specificity of the project. This test has enabled us to check if there are any statistically significant differences among the result variables and the variables of identification of the project.

## 3. Results

### 3.1. Typology of Programs

This is a heterogeneous sample originating from public ( $n = 144$ ; 73.09%) and private entities ( $n = 53$ ; 26.90%), implemented internationally, which tackles different categories of heritage (see Table 4) and which encompasses 17 typologies of educational design (see Table 5). All of the programs which make up the sample deal, in part or totally, with different categories of heritage education and also reflect the use of virtual environments, VR and AR.

**Table 4.** Frequencies obtained according to heritage category.

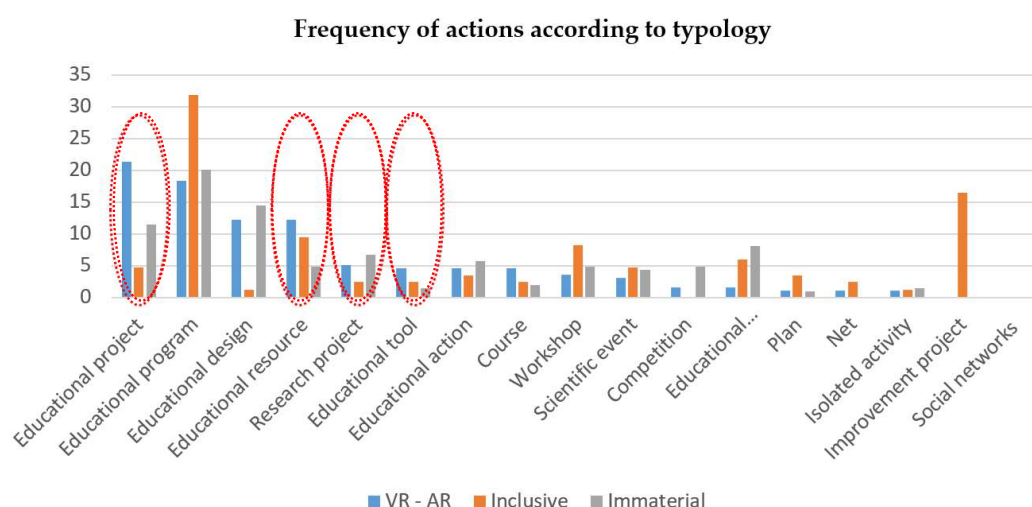
Code	Heritage category	Frequency
1	Cultural	111
2	Immaterial	29
4	Natural and cultural heritage	14
6	Monuments: Architectonic works	10
7	Monuments: Archaeology	9
5	Archaeological sites	7
3	Places: created by man	6
9	Digital heritage	5
8	Monuments: Pictorial works	2
10	Monuments: Cave art	1
11	Ensembles: Isolated constructions	1
12	Monuments: Group of elements of importance	1
13	Cultural and natural	1

In relation to the typology of the educational designs which make up the sample, a greater frequency is detected for those which are defined as educational projects (21.31%), programs (18.27%), and educational designs (12.18%). This piece of data is a common denominator in all of the studies extracted from the observatory's database, independently of the descriptors which define the search, as these suppose a high percentage of the total sample. However, the appearance of educational

resources (12.18%) among the three most frequent typologies is worthy of note. This detail is a differential indicator, due to the fact that this typology does not appear in all cases. Rather, it depends on the descriptors of the search which define the sample. With the aim of contrasting these results with previous studies [48,49], a statistical graph was created (see Figure 1) which allows us to obtain the trends for each typology of program. In this case, a slight increase in frequency can be observed in comparison with other studies in the cases of educational resource and educational tool, both of which are teaching aids to facilitate the teaching and learning processes in educational activities and, furthermore, should ensure interaction on the part of the learner [10]. Therefore, it seems clear that using VR and AR in an attempt to bring heritage environments closer to the classroom in order to achieve existential experiences supposes an increase in these typologies. Also worthy of note is the increase in research projects which elaborate on issues of new forms of information technology (ICT) and new technology for learning and knowledge (TLK) in response to the inclusion of VR and AR in learning processes. Finally, the absence of improvement projects must be highlighted, given that in the same way as research projects, VR and AR should be one of the main objectives for achieving the advancement and improvement of the quality of education, as well as going more deeply into programs which respond to the descriptors of inclusion and attention to diversity.

**Table 5.** Frequencies obtained according to typology of educational design.

Code	Typology	Frequency
2	Educational project	42
1	Educational program	36
3	Educational design	24
4	Educational resource	24
9	Research project	10
5	Educational tool	9
6	Educational action	9
16	Course	9
8	Workshop	7
15	Scientific event	6
11	Competition	5
12	Educational itinerary/route/visit	5
13	Plan	4
14	Net	4
7	Isolated activity	3
10	Improvement project	0
17	Social networks	0



**Figure 1.** Frequency of actions according to typology.



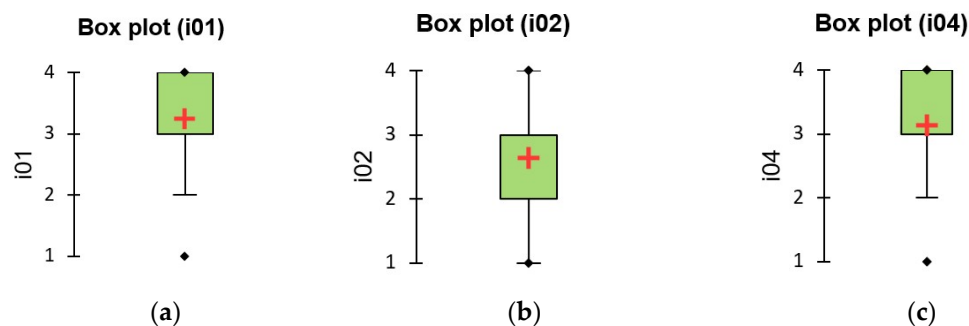
### 3.2. Assessment of the Quality of the Programs

In general, the assessment carried out by the items via the Q-Edutage scale shows an extremely low opinion of heritage education programs which use virtual environments, VR, and AR (see Table 6). Only two items were scored above an average of three points, with only one program achieving a score of between 2.5 and three points. Eleven of the fourteen items received scores below 2.5 and a median of two or one (in other words, they did not achieve a sufficient level of quality, or only did so with conditions).

**Table 6.** Statistics of the items which make up the Q-Edutage scale.

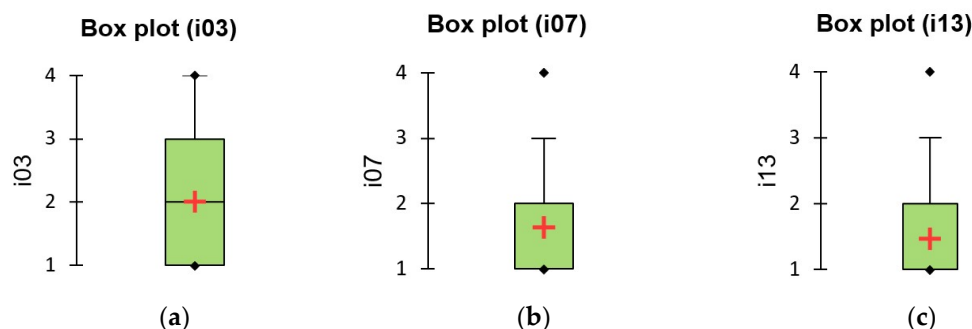
Statistic	i01	i02	i03	i04	i05	i06	i07	i08	i09	i10	i11	i12	i13	i14
Number	197	197	197	197	197	197	197	197	197	197	197	197	197	197
Minimum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00
Maximum	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Median	3.00	3.00	2.00	3.00	2.00	2.00	1.00	2.00	2.00	2.00	2.00	2.00	1.00	2.00
Average	3.24	2.63	2.01	3.13	2.36	2.19	1.64	2.42	2.30	2.35	2.30	2.08	1.47	2.27
Variance (n)	0.60	0.99	0.84	0.88	1.01	0.65	1.04	0.95	0.67	1.15	1.19	1.08	0.69	0.31
Typical deviation (n)	0.77	1.00	0.92	0.94	1.01	0.81	1.02	0.98	0.82	1.07	1.09	1.04	0.83	0.56
Asymmetry (Pearson)	−0.57	−0.10	0.49	−0.77	0.20	0.56	1.25	0.09	0.45	0.28	0.27	0.46	1.63	1.92

The three Items with the highest scores are 1, 2, and 4 (see Figure 2). These items are mainly related to the identification of the program and the contact information. As can be seen in figures a (i01 contact), b (i02 descriptors) and c (i04 typology), the interquartile range (Q1–Q3) is situated between three and four points in Items 1 and 4 (a–c), and between two and three points in Item 2 (b). Therefore, the majority of the programs reached the level of quality required for these items of identification.



**Figure 2.** The most notable box plots: contact, descriptors, and typology. (a) (i01 contact); (b) (i02 descriptors); (c) (i04 typology).

The three items with the lowest scores were 3, 7, and 13: holistic conception of heritage, annexed documents, and determination of assessment systems (see Figure 3). As can be seen in figures a (i03 heritage), b (i07 annexes), and c (i13 assessment), the interquartile ranges of the scores for these programs are situated between one and two in the case of the items on annexed documentation and assessment systems, and between one and three points for the case of the holistic conception of heritage. In other words, a large proportion of these programs did not fulfil the quality criteria, or only did so with conditions. It is also important to point out that all of the items on the educational design of the program (objectives, contents, methodology, materials and resources, and evaluation) have an average score of between two and 2.5 and a median of two or one, in other words, all these items are reached with conditions that imply a very superficial design of the programs. In the assessment carried out of the programs which use virtual environments, VR, and AR, very few fulfilled the criteria for quality required in the educational design.



**Figure 3.** The most insufficient box plots: heritage, annexes, and assessment. (a) (i03 heritage); (b) (i07 annexes); (c) (i13 assessment).

### 3.3. Correlations in the Assessment of the Quality of the Programs

The table of Pearson correlations (see Table 7; Table 8) shows moderate to high correlation coefficients among all of the items, with the exception of Item 1, which has low correlations (between 0.17 and 0.25) with the other items. The rest maintain statistically significant coefficients as can be seen in the table of  $p$ -values. Thus, 87 of the 89 correlations have values  $p < 0.05$ .

**Table 7.** Pearson coefficient correlation.

Variables	i01	i02	i03	i04	i05	i06	i07	i08	i09	i10	i11	i12	i13	i14
i01	1.00													
i02	0.25	1.00												
i03	0.25	0.41	1.00											
i04	0.29	0.29	0.40	1.00										
i05	0.19	0.53	0.50	0.34	1.00									
i06	0.22	0.32	0.33	0.26	0.35	1.00								
i07	0.19	0.39	0.40	0.25	0.53	0.36	1.00							
i08	0.17	0.50	0.48	0.31	0.88	0.34	0.59	1.00						
i09	0.21	0.41	0.33	0.29	0.60	0.37	0.51	0.56	1.00					
i10	0.25	0.33	0.37	0.27	0.59	0.39	0.53	0.55	0.67	1.00				
i11	0.27	0.36	0.40	0.33	0.59	0.46	0.50	0.59	0.56	0.53	1.00			
i12	0.20	0.40	0.49	0.33	0.54	0.37	0.52	0.54	0.56	0.56	0.62	1.00		
i13	0.21	0.39	0.47	0.26	0.49	0.36	0.41	0.45	0.49	0.39	0.50	0.52	1.00	
i14	0.24	0.33	0.39	0.24	0.41	0.33	0.52	0.44	0.38	0.30	0.49	0.38	0.49	1.00

**Table 8.** *P*-values of the Pearson correlation table.

[illegible]



The highest correlations are among items related to the implementation of the educational design of heritage education programs (Items 9–13): the implementation of educational objectives, contents, methodology, resources, and evaluation and impact of the proposal. The correlations among these items are located between 0.50 and 0.67 and all of them have  $p$ -values  $<0.01$ . As can be seen in the image of the correlation matrix (see Figure 4), the greatest correlations arise among these items (light green). It can also be observed how Items 1 and 4 are those which present a lower correlation coefficient with the rest (these are items of identification). From these data, it is observed how the items of the educational structure (Items 9–13) find a very positive correlation, which means that regardless of the degree of scope in which they are made explicit, they are related and the proper unit of design between its parts.

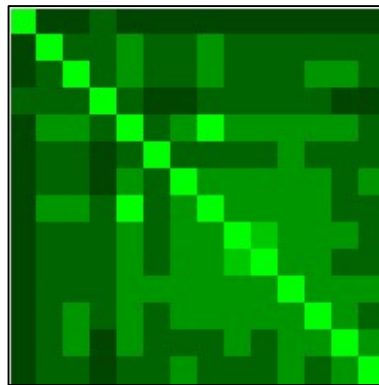


Figure 4. Image of the correlation matrix.

### 3.4. Hypothesis Testing

The following detail the hypothesis tests that determine the differentiation between the quality of the programs based on the typology of the institution and between the specificity of the program are detailed, as they are integrated into its conception in a general or specific way the virtual environments, VR, and AR.

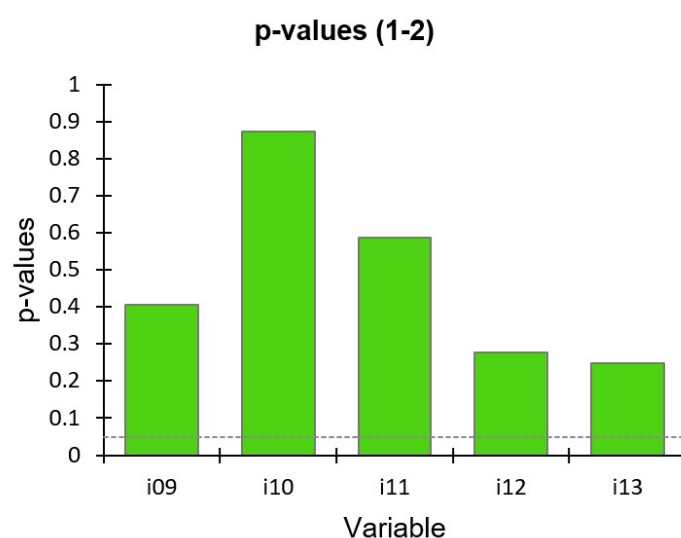
#### 3.4.1. Public/Private

For hypothesis testing, items on the educational design of the program were selected as, on the whole, they present a similar average (under 2.5) and high correlation coefficients. This demonstrates a high consistency between the elements which define the educational structure of the program as units of information which are designed and systematically recorded and organised [50].

In order to determine the existence of differentiated values between the publicly (73%) and privately (27%) funded programs, the items relating to the educational design were compared. As can be seen in Table 9, no big differences were found. The items with the biggest differences concern the description of the objectives and the systems or tools for evaluation, the quality of which are slightly lower in the privately funded programs. One reason for this may be the need for transparency in projects which belong to public institutions. As a consequence, the publicly funded programs include a larger quantity of information. However, as can be observed, the average differences are not high. The Mann–Whitney U test (see Figure 5) shows that this difference is not statistically significant in items which define the educational design of the program ( $p > 0.05$  in all of the items).

**Table 9.** Descriptive statistics of the items regarding the educational design of the program according to whether it is public or private.

Variable	Observations	Minimum	Maximum	Mean	Typical dev.
i09   Public	144.00	1.00	4.00	2.34	0.86
i09   Private	53.00	1.00	4.00	2.21	0.69
i10   Public	144.00	1.00	4.00	2.35	1.09
i10   Private	53.00	1.00	4.00	2.36	1.04
i11   Public	144.00	1.00	4.00	2.33	1.11
i11   Private	53.00	1.00	4.00	2.23	1.05
i12   Public	144.00	1.00	4.00	2.03	1.04
i12   Private	53.00	1.00	4.00	2.21	1.04
i13   Public	144.00	1.00	4.00	1.51	0.85
i13   Private	53.00	1.00	4.00	1.36	0.76

**Figure 5.** P-values of the Mann–Whitney U test of items concerning the educational design of the program according to whether it is public or private.

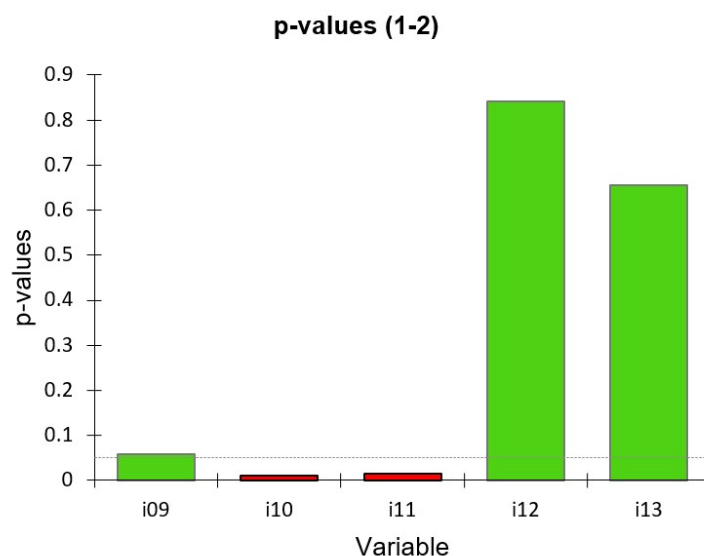
### 3.4.2. Specificity of the Program

In regards to the specificity of the programs, the average differences according to the subsamples determined by the programs which partially reflect the inclusion of those technologies ( $n = 113$ ) and those which do so specifically ( $n = 84$ ) are only notably shown in the presentation of contents (i10) and the methodological orientation and strategies of teaching and learning (i11), as seen in the following Table 10.

**Table 10.** Average differences between the items concerning the educational design of the program according to whether the descriptor appears generally or specifically.

Variable	Observations	Minimum	Maximum	Average	Typical dev.
i09   General	113.00	1.00	4.00	2.42	0.84
i09   Specific	84.00	1.00	4.00	2.15	0.77
i10   General	113.00	1.00	4.00	2.51	1.04
i10   Specific	84.00	1.00	4.00	2.13	1.08
i11   General	113.00	1.00	4.00	2.47	1.11
i11   Specific	84.00	1.00	4.00	2.08	1.03
i12   General	113.00	1.00	4.00	2.11	1.09
i12   Specific	84.00	1.00	4.00	2.05	0.98
i13   General	113.00	1.00	4.00	1.47	0.88
i13   Specific	84.00	1.00	4.00	1.46	0.77

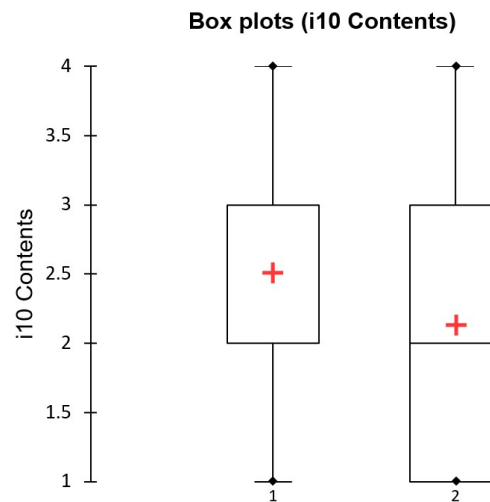
In these items, there is a better assessment of the programs of a general nature than of those which are specific. We believe that this responds to the fact that the programs which more clearly or more specifically show the use of virtual environments, virtual reality, or augmented reality place the focus of their attention on this product, which, on the whole, are applications included in the typologies of resource or educational tool, paying less attention to methodological description or to content. It seems that, in these programs, the focus on technology comes to the detriment of educational specificity. This specificity is achieved more satisfactorily when the use of these technologies is only named as part of the development of the program, not as the main element. The Mann–Whitney U test (see Figure 6) shows that the average differences of Items 10 and 11 regarding the specificity of the program are statistically significant ( $p < 0.01$  in the case of Item 10 and  $p = 0.01$  in the case of Item 11).



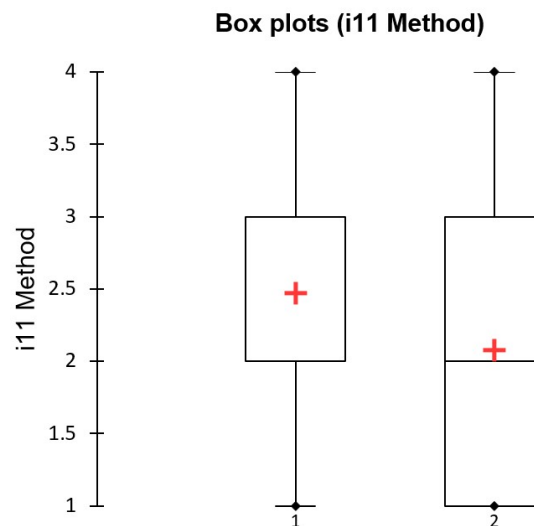
**Figure 6.** P-values of the Mann–Whitney U test of items concerning the educational design of the program according to whether the descriptor appears generally or specifically.

As can be observed in Figure 7; Figure 8, the interquartile range of Variables 10 and 11 in the general programs are located between two and three points, in other words, the degree of quality expected “is achieved” or “is achieved with conditions” in the case of programs that superficially integrate the tools. However, this range in the specific programs, those that deal only with the tool as the main element with its more technical characteristics, is situated between one and three points, which implies that there is a large number of programs in the latter case which do not achieve the quality standards. Therefore, there is a higher level of educational specificity in general programs that give priority to educational design in which the tool is only a resource of the program and appears on a secondary level.

It should be mentioned that educational quality was not achieved in any of the cases. The averages show that all of the items were achieved with conditions, with the highest scores being achieved by the description of the objectives (i09), the contents (i10), and the methodological orientation (i11). A level of quality was not achieved for the determination of systems or assessment tools (i13). The definition of a quality design should imply a greater degree of specificity in all aspects.



**Figure 7.** Box plot of the average score of Item 10 (presentation of the contents of the programs) according to whether the program is general or specific.



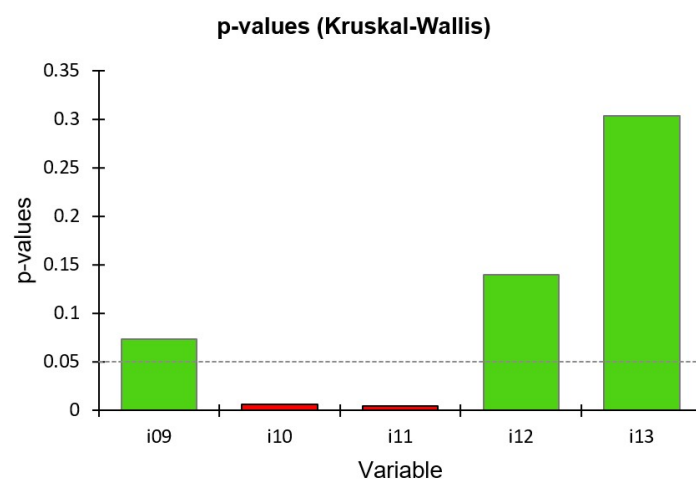
**Figure 8.** Box plot of the average score of Item 11 (presentation of the contents of the programs) according to whether the program is general or specific.

### 3.4.3. Type of Project

As in the previous case, the descriptive data of the averages only show notable differences between Items 10 and 11 according to the variable “type of project”. Although the typology of the project is not dealt with in a homogeneous manner, given that a significant part of the sample are programs (1), projects (2), educational designs (3), or resources (4), there were notable differences in the analysis between items according to their typology (see Table 11). The KruskalWallis test (see Figure 9) confirms that the average difference between Items 10 and 11 and the type of project is statistically significant ( $p = 0.01$  in the case of Item 10 and  $p < 0.01$  in the case of Item 11).

**Table 11.** Average differences between Items 10 and 11 according to type of project.

Variable	Observations	Minimum	Maximum	Average	Typical dev.
i10   1	36.00	1.00	4.00	2.19	0.89
i10   2	42.00	1.00	4.00	2.33	1.14
i10   3	24.00	2.00	4.00	3.25	0.85
i10   4	24.00	1.00	4.00	2.08	1.10
i10   5	9.00	1.00	4.00	2.00	1.32
i10   6	9.00	1.00	4.00	2.22	1.09
i10   7	3.00	1.00	2.00	1.33	0.58
i10   8	7.00	1.00	4.00	2.00	1.15
i10   9	10.00	1.00	3.00	1.90	0.88
i10   11	5.00	2.00	3.00	2.40	0.55
i10   12	5.00	1.00	3.00	2.00	0.71
i10   13	4.00	1.00	3.00	2.00	0.82
i10   14	4.00	1.00	4.00	2.25	1.50
i10   15	6.00	1.00	4.00	3.00	1.10
i10   16	9.00	1.00	4.00	2.89	1.05
i11   1	36.00	1.00	4.00	2.64	0.99
i11   2	42.00	1.00	4.00	2.33	1.20
i11   3	24.00	1.00	4.00	3.08	0.97
i11   4	24.00	1.00	4.00	1.96	0.91
i11   5	9.00	1.00	4.00	1.89	1.17
i11   6	9.00	1.00	4.00	2.33	1.00
i11   7	3.00	1.00	2.00	1.33	0.58
i11   8	7.00	1.00	3.00	1.71	0.76
i11   9	10.00	1.00	4.00	2.40	1.17
i11   11	5.00	1.00	3.00	2.00	1.00
i11   12	5.00	1.00	2.00	1.40	0.55
i11   13	4.00	2.00	4.00	2.50	1.00
i11   14	4.00	1.00	4.00	1.75	1.50
i11   15	6.00	1.00	3.00	2.00	0.89
i11   16	9.00	1.00	4.00	1.78	0.97

**Figure 9.** P-values of the Kruskal–Wallis test for items concerning the educational design of the program according to typology of project.

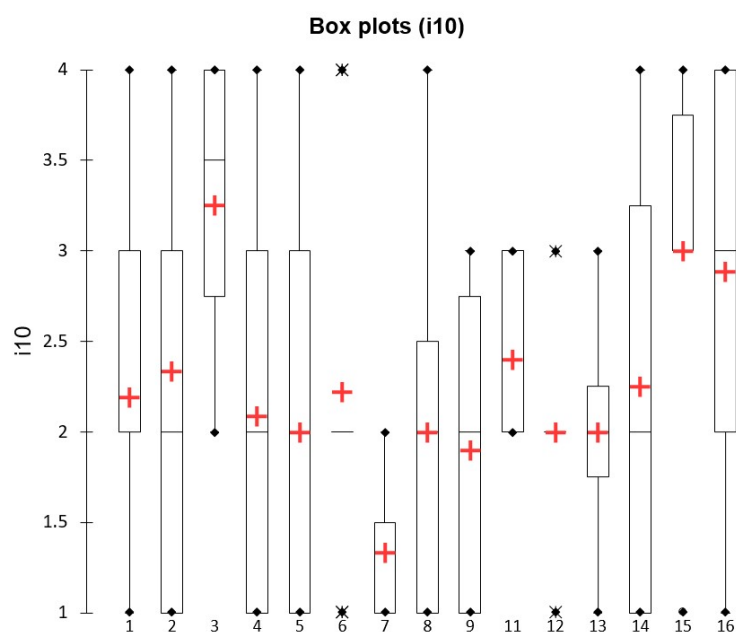
First of all, we analysed Item 10 referring to the presentation of contents, which has its highest value in Typology 3 (educational design). This result confirms one of the initial hypotheses, given that the educational design is defined as a document which provides structure to an educational intervention, specifying objectives, procedures, and contents. Therefore, this typology should presumably have the highest score. However, this is not achieved by other programs which organise an educational process, which join together a set of systematically planned activities or which are aimed at achieving defined

objectives: educational program or educational project. With the exception of the educational design, an average of three was only reached for Item 15, which corresponds to the typology of scientific events. In this type of programs, the contents addressed are necessary to transmit the lines of interest to the attendants and participants. It must also be pointed out that the most pronounced typical deviations arise in Item 5 (educational tool) and Item 14 (networks).

As far as the tool is concerned, the specificity is extremely variable, given that it is a tool which facilitates or makes possible an item of learning or its teaching and that, on occasions, it is only defined because it can be applied in different contents according to teachers' needs. Networks, on the other hand, are proposed from different areas (Networks of Schools, Networks of Museums, Virtual Networks, etc.) with each one focusing its bases in very different ways. Therefore, the information provided may present disparity to a greater or lesser degree depending on each case.

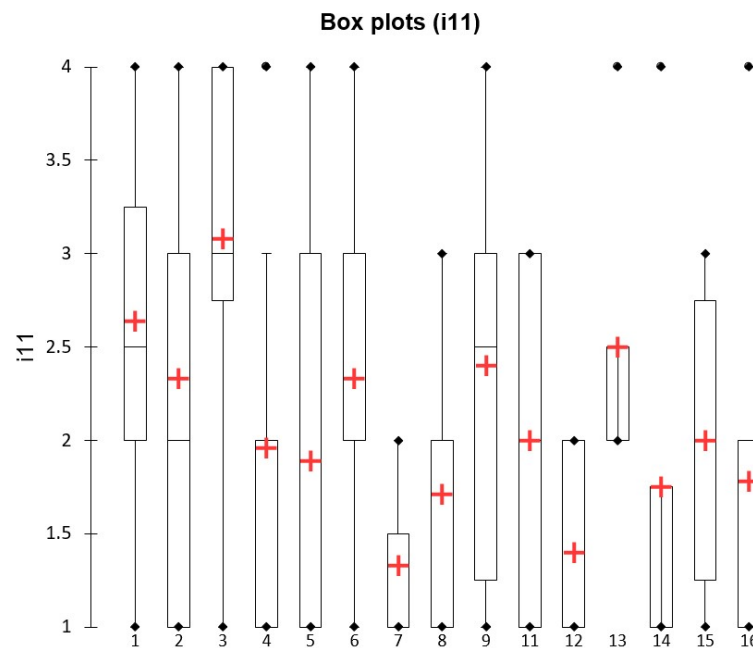
Secondly, we analysed Item 11, referring to methodological orientation. Again, the typology of educational design stands out as far as the average score is concerned due to the same reasons described above. Apart from the educational design, no other typology achieved an average score of three. Indeed, only the typology of educational program achieved an average score of more than 2.5, complying with its definition as a document which makes it possible to detail and organise an educational process. This type of program generally arises in informal contexts. Therefore, it should integrate the methodology and strategies of teaching and learning and also foresee and plan its continuity. In this case, we were surprised to find that the most noticeable result of the typical deviation is found in the program corresponding to educational project. The most evident explanation for this is that this type of planning responds to short to medium-term programs, are characterised by a projective condition towards the achievement of research and development objectives and, therefore, the most pronounced aspect of its description are the objectives, subordinating, in some cases, the description of contents or of methodological orientation and leading to a great dissimilarity in quality.

As can be observed in Figures 10 and 11, the highest interquartile ranges in the presentation of contents are attained by educational designs, courses and scientific events. On the other hand, the lowest interquartile ranges are found in educational project, educational resource, educational tool and networks. In the case of the assessment of the methodology presented by the program, the highest interquartile range is reached in educational design, whereas the lowest ranges are found in courses, networks and isolated activities.



**Figure 10.** Box plots of the average scores of Item 10 (presentation of contents addressed) according to the typology of the program.





**Figure 11.** Box plots of the average scores of Item 11 (presentation of contents addressed) according to the typology of the program.

#### 4. Discussion and Conclusions

After analysing all of the variables of the study and applying the Q-Edutage scale, the results underline the fact that there is a coherence between the items which make up the educational structure of the programs [50,51], although their quality is average or low. A large proportion of the programs assessed do not achieve the level of quality required in terms of their educational design, or only do so with conditions. The results are an improvement in comparison with other previous studies [48,49,52] and, given that the design of the programs which make up the sample corresponds to the most up-to-date designs, this can be interpreted as a gradual improvement in the conceptualisation of educational proposals. However, aspects such as the overall focus of the heritage [53–55] or the internal assessment of the programs continue to be aspects in need of improvement, as has already been shown by previous studies [48,49,52,56–58].

In the preparation stage of this study, one of the initial hypotheses suggested that all of the programs containing the search descriptors would be confined to a virtual learning environment (VLE), meaning that all of them allow for educational interactions on the internet. However, after the analysis of the contents of the description of the programs specifically reflecting the use of environments, virtual resources, and/or AR, it can be concluded that only 44% of them contained virtual contexts, platforms, environments, spaces, and communities in their description. Of these, although the majority describe only the learning of the user, only some point towards the exchange, digital twinning, and creation of networks as learning strategies. The remaining 56% do not correspond to educational proposals developed in virtual environments. Rather, they allude to the use of digital educational resources and tools integrated within them.

In this second group, the incorporation of museums, exhibitions, and virtual rooms (24%) stands out, along with the development of virtual itineraries (virtual route/walk/tour/trip are the terms recorded) (13%), the use of virtual reality (9.5%), virtual visits to digitalised environments (7.14%) and, to a lesser extent, the use of virtual guides, replicas, recreations, reconstructions, the digitalisation of monuments and 3D objects, virtual educational material, apps and virtual games, and interactive virtual tools.

As far as the term AR is concerned, its use is only explicit in a minority of the programs (3.57%). However, due to their similarities, in many cases, these terms are used as synonyms. This implies that

these concepts are not clear for those who design the proposals, given that “augmented reality” (AR) enables the users to visualise elements or spaces via a digital device in the real world [17] and “virtual reality” (VR) transports the user to a projected context which may be immersive [14] via physical accessories such as glasses or headphones. In turn, we consider that this analogy in terms can be extended in society as it is an emerging technology [59,60].

After analysing the possibilities that the projects show with the implementation of virtual technologies, certain aspects stand out: the elimination of barriers of space and time, facilitation in the exchange of experiences among users, cooperation and collaboration among agents, the opening of new paths for transmission and communication, an increase in motivation, the development of attitudes of awareness and respect towards the role of heritage, the appearance of new ways of approaching heritage and educational experiences, and new forms of interaction. Last of all, one aspect which is repeated in many cases must be highlighted: the inclusion provided by new technologies in promoting the understanding of cultural assets and the global accessibility to heritage environments, which, in contrast, presents a low manifestation in the “accessibility” variable, which is only explicit in 7.6% of cases. The presence of adapted material and human resources in the programs is almost non-existent, which is one aspect for imminent improvement, both in their development and in their presence in the educational design, an indicator which has already been detected and which does not show any progress.

From this analysis, certain unavoidable necessities can also be extracted which authorities and institutions must bear in mind if they are to play an active role in the management, support, and financing of these applications to promote their implementation for the benefit of teaching: that (a) develop policies for incorporation, application, and development of virtual environments to heritage cultural; (b) promote research initiatives and projects on the effects of the use of virtual environments, VR and AR in the dissemination of cultural heritage; and (c) boost research on models, interactive designs and virtual prototypes to allow knowledge of heritage to be possible for a wide spectrum of the population.

Finally, it should be pointed out that some of the conclusions included here were drawn from variables which were not dealt with in a detailed manner during this study, but which were observed during the prior analysis of the programs and were deemed relevant. Among them, we can highlight the audiences which the majority of the programs are aimed at, given that the implementation of these technologies is closely related to digital natives. The biggest range of target users consists of the stages of compulsory education, particularly young people of between 14 and 20 years of age: compulsory secondary education and baccalaureate (25.9%), primary education (19.8%), and “all audiences” including those mentioned previously (25.9%). This high percentage is a clear indicator of the educational context in which these virtual learning environments and technological resources are developed. Programs which do not provide data on the community, population, or audience which the project is aimed at (16.7%) were excluded from the sample and the remaining percentage refers to specific audiences of different kinds (11.7%).

The final conclusion to be drawn alludes to the category of heritage which the programs refer to (see Table 4). In this regard, according to their frequencies, 56.3% of the programs are aimed at cultural heritage. Although it is true that the majority of the programs deal with historical, cultural, and artistic heritage, this aspect is a common denominator in the different assessment studies, the main cause of which can be considered to be that a high number of institutions use the term cultural heritage generically as a container for different categories and kinds of heritage.

To conclude, following the analysis and the review of literature, it can be stated that these cutting-edge technologies are extremely costly to perfect and implement; this is currently an embryonic field whose funds are mainly assigned to the documentation, reconstruction, restoration, and dissemination of heritage [61]. In the field of education, there are many more steps to take, but this research has enabled us to define the state of the art, to identify variables, to identify the quality of the educational proposals

which currently exist, to extract the main advantages of the use of virtual environments (VR and AR), and to unravel key necessities with the perspective of educational improvement.

**Author Contributions:** Conceptualization, C.J.G.-C.; Funding acquisition, A.I.-E. and C.J.G.-C.; Investigation, O.F.; Methodology, S.G.-C.; Project administration, O.F.; Resources, O.F.; Supervision, A.I.-E.; Visualization, S.G.-C.; Writing—original draft, C.J.G.-C. and S.G.-C.; Writing—review & editing, A.I.-E. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was carried out with the aid of funding from the Spanish Ministry of Science, Innovation and Universities, and was co-funded by ERDF funds from the European Union for the research projects EDU2015-65716-C2-1-R, EDU2015-65716-C2-2-R, and PGC2018-094491-B-C33. It has also been made possible by funding from the Fundación Séneca of the Region of Murcia for the project 20638/JLI/18 and the Education Department of the Regional Government of the Basque Country (IT1193-19).

**Conflicts of Interest:** The authors declare no conflict of interest. The funders had no role in the design of the study, in the collection, analyses, or interpretation of data, in the writing of the manuscript, or in the decision to publish the results.

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